N.A.A.S. QUARTERLY REVIEW

NUMBER

29

Autumn 1955

London
Published for the
Ministry of Agriculture, Fisheries & Food
by Her Majesty's Stationery Office

PRICE 1*s.* 6*d.*

AGRICULTURAL RESEARCH COUNCIL

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N.A.A.S.
QUARTERLY REVIEW

The Journal of the National Agricultural Advisory Service

NO. 29 AUTUMN 1955

Contents

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LONDON : HER MAJESTY'S STATIONERY OFFICE : 1955

REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

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Livestock Breeding in the United States

N. F. MC CANN

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THE SCOPE AND SCALE of the livestock breeding programme in the U.S.A. is enormous. The Federal Government has livestock breeding research centres in all parts of the United States as well as large undertakings at the Agricultural Research Centre at Beltsville, near Washington, D.C., and each of the forty-eight states may have a research programme of its own. The Department of Agriculture has no direct control over the state projects, but the work at Beltsville is co-ordinated for each type of livestock with that of the Federal stations and the individual states. The value of these co-ordinated experiments on such a vast scale needs no emphasis: at the same time the size of the programme makes it possible to give only a brief outline of what is being done.

Beef Cattle

Extensive resources devoted to research on beef cattle breeding have as their objective the assessment of:

the value of selection in improving the economically important characteristics of beef cattle;
the value of inbreeding, out-breeding and cross-breeding in beef production;
the relationship between performance and such factors as size, conformation, rate of gain, economy of gain and fertility;
the link between carcass value and measurements, both alive and dead;
the importance of environmental and genetic relationships;
the value of existing breeds and strains;
methods of eliminating inherited defects.

Thirty-eight states, the Territory of Hawaii, and six Federal stations are devoting attention to these problems. Much of the work is carried out by a system of mass selection. Large numbers of bulls are checked for birth weight, weaning weight, weight at twelve months, feed consumption and rate of gain. Comparisons are made between the progeny of the bulls with the best performance and those with the worst performance, and it is claimed that rate of gain has heritability of about 22 per cent in steers fed indoors and 12 per cent in heifers tested on pasture. Bulls tested in South Dakota show—in terms of beef production by their progeny—highly significant differences in rate of gain and dressing percentage. A study of the intensity of red colour in Hereford cattle indicates heritability of about 70 per cent.

Over a ten-year period it was demonstrated by experiments in Montana that there is a real possibility of improving important

production characteristics of beef cattle through line selection. In this study birth weight, weaning weight, average daily gain, efficiency of gain, final weight, slaughter grade, carcass grade, shipping shrink, dressing percentage, colour of lean meat, area of eye muscle, thickness of fat over the eye muscle and body measurements were all considered, and each factor was correlated with all the others. There were significant differences in lines of cattle in all these factors except shipping shrink.

Investigations in the southern states are devoted to evaluating strains of both pure-bred and cross-bred cattle best adapted to the environment of the region bordering the Gulf of Mexico. The breeds under test are Brahman, Angus, Africander and crosses of Angus with the other two. Herd sire replacements are based on performance tests conducted with bull calves each year. Two main types are being produced—a red Africander-Angus cross and a Brahman-Angus cross which may turn out to be grey. The animals are mated with no regard to the proportions of the blood of the two breeds within each main type, and no attempt is being made to fix a type. It is conceivable that this project will end up with two polled breeds, one grey and one red, differing very little in type, conformation or fattening ability.

An interesting development of recent years is the establishment, as a breed, of the Shorthorn-Brahman cross known as the Santa Gertrudis. In spite of their size, these animals are very hardy, will live on very poor forage, will travel long distances to water, and are very resistant to ticks and tolerant to heat. The Brangus, a cross of Brahman and Angus, and the Beefmaster, a three-way cross of Brahman, Hereford and Shorthorn, exhibit the same hardy characteristics.

The principal British breeds of beef cattle in America have been selected for generations to provide a very short-legged, blocky type and, as a result perhaps of breeding for these characteristics, dwarfism has become a problem. Animals of either sex may carry this factor; dwarfism occurs most frequently when two carriers or heterozygotes are mated together, but it may also appear when a carrier is mated to a normal animal. An attempt to diagnose dwarfism in a herd by test matings may be both costly and inconclusive. In the western states there has been developed a profilometer which is used to measure the convexity of the bull's forehead, a characteristic related to dwarfism. The value of this instrument is not generally accepted, but, within its limitation, it is no doubt helping to detect dwarfs. In Iowa it has been noticed that dwarf animals all have a malformation of the lumbar vertebrae, which is easily detectable under X-ray. This observation is being checked by breeding experiments with dwarfs and heterozygotes.

An important development is the interest in producing polled strains of the horned European breeds. The Polled Hereford, for instance, is making rapid strides: care has been taken to maintain complete purity of line within the Hereford Herd Book and these animals will undoubtedly attract increasing attention from buyers all over the world.

Dairy Cattle

In 1954 the results of fifteen years of cross-breeding experiments with dairy cattle were published. Proven sires of Friesian, Jersey and Red Danish breeds were bred to females of these three breeds and also to Guernsey cows and all succeeding generations of cross-bred females. Substantial increases in milk and fat production were achieved. The pattern of sire-breed rotation was found to be of no importance; the key to continuing improvement lies in the quality of the bull. Now, proven cross-bred bulls, one containing blood of all four breeds, are being used on the cross-bred cows, many of which have completed the cycle of four-breed crossing. This work will continue without attempting to record the proportion of breeds in the crosses, and the cross-bred bulls will be used on pure-bred cows to see if hybrid vigour will result from such matings.

In the breeding herd of Friesian cattle at Beltsville, and in a Jersey herd in Tennessee, the influence of varying management has been reduced as far as possible—amongst other things by indoor feeding all year round. By the use of proven sires the herd average at Beltsville has been raised to just under 1,700 gallons per cow per year with a butterfat yield of slightly less than 700 lb. Bulls bred in this herd have been progeny tested in commercial herds. Seventy-nine per cent of the sires had daughters whose average milk production was higher than that of their dams, and 71 per cent had daughters whose butterfat production exceeded that of their dams.

It may fairly be said that breeding has got ahead of management; that is, only a small proportion of milk producers are able to make full use of the potential abilities of the cows they breed or buy and, until the general level of management is improved, full advantage will not be taken of the breeding material made available by the practice of artificial insemination.

Crosses of Jersey, Brown Swiss and Holstein with Sindhi cattle in varying proportions are under test to determine and improve heat tolerance. So far, it has been impossible to determine exactly the factors which give the exotic breeds greater heat tolerance than the British breeds, but it is noticeable that many herds of Jersey cattle, more or less purebred, exhibit sufficient heat tolerance to enable them to thrive in the semi-tropical areas of the United States. More attention to management and selection within the existing herds of Jerseys might give a quicker improvement in milk production than would the introduction of the low-milk-producing ability of the Sindhi.

The Holstein and Brown Swiss cattle have been introduced into the south to cross them with the Sindhi and to compare them under hot, humid conditions with the Jersey, which has, as noted above, achieved some heat tolerance. Although it is possible that these mixtures of European and Zebu blood may lead to the development of a high-yielding, heat-tolerant type, it is more likely that these studies will prove of most value in determining the mechanism of heat tolerance.

Sheep

Research with sheep follows two main lines: firstly, the comparison of different systems of breeding and development of more effective methods of selection and, secondly, the formation of inbred lines of certain breeds. Comparisons are being made between inbred lines formed by selection within lines and by recurrent selection of sires from line-cross and top-cross progeny tests. At the Range Sheep Station in Idaho the breeds mainly used are the Rambouillet, the Columbia, which is a cross of Rambouillet and Lincoln, and the Targhee, which is a cross of Columbia, Corriedale, Lincoln and Rambouillet. Selection against neck folds in Rambouillet sheep resulted in a definite decrease of this condition, and at present selection is going on against wool blindness, since it has been found that as much as 11 lb. more liveweight of lamb per year may be expected from an open-faced ewe compared with one blinded by wool. Selection in the Rambouillet has improved the wool by eradicating coarse breach wool and increasing the length of staple. In the Columbia breed, selection is proceeding for uniformity and density of wool and for better mutton production. The Targhee is being selected for improved wool quality.

At the United States Department of Agriculture's Research Centre at Beltsville, crosses of Hampshire, Shropshire and Southdown sheep are being made to compare the production of pure-bred sheep with that of the first crosses between two purebreds and three-way crosses produced by mating first-cross ewes with rams of the third breed. For each 100 lb. of lamb meat produced by the pure-bred lambs, the first cross produced an average of 108.9 lb. Cross-bred ewes bred to rams of the third breed were still more productive, giving an average of 123.1 lb. A pure flock of Merinos is maintained and Merino rams are being bred to Hampshire × Shropshire cross-bred ewes. A breed known as Southdales was developed during the 1930s and early 1940s by crossing Southdowns and Corriedales, and ewes of this breed are now being bred to Columbia rams with the intention of producing a new breed. The Southdale ewe flock was divided into four sections, respectively mated to four unrelated Columbia rams. The crosses from each generation within the section are mated to rams or ewes of the same generation in other sections. This programme is now in the third generation and at the fourth generation it is expected that the type will be fixed and a new breed formed. This will be a sheep slightly larger than the Shropshire, with good meat- and wool-producing qualities.

In New Mexico, on the sixteen-million-acre Navajo Indian Reservation, a breeding programme is being carried out to restore the wool characteristics of the old Navajo breed so that the wool can be used for the traditional handicrafts of the tribe. Originally introduced by the Spaniards, the Navajo breed has sadly deteriorated over the last hundred years.

Pigs

The principal objectives of the research programme are to discover, develop and test procedures of breeding and selection which may be used commercially to breed better pigs; to investigate the usefulness of inbred lines for improving the breeding value of purebreds and to ascertain the genetic effects of inbreeding. The abundance of maize and the shortage of labour in the United States resulted in pigs receiving an unrestricted and very starchy diet. Since the bacon factories cut off the eye muscle for sale as fresh pork and trim the fat to a marketable depth above the "streak" in the bacon, thickness of fat was formerly of no importance, all the surplus being cut away with the skin and used for industrial processes, much of it going to soap-making. In recent years the immense increase in the use of detergents has hit the soap industry very hard and, in turn, the industrial outlet for fat has been reduced. Pig-feeders are trying to meet the new situation by purchasing high protein supplements to feed with the maize, but they cannot introduce controlled feeding and so breeders are trying to breed the fat off the pigs. In Minnesota, two inbred lines were formed from cross-bred foundations, the first from Danish Landrace and Tamworth to combine the long body and good ham of the Landrace with the colour, prolificacy and milking ability of the Tamworth. This line, which contains roughly 48 per cent Landrace and 52 per cent Tamworth, was designated a new breed in 1946 and named Minnesota No. 1. The second Minnesota line was established from a cross of Canadian Large White and two inbred lines of Poland China pigs. The resulting animals are about 40 per cent Large White and 60 per cent Poland China, and this line was recognized as a new breed, Minnesota No. 2, in 1948. The main purpose of creating this second breed was to cross it with the Minnesota No. 1 on the assumption that the advantages of crossing would be increased by using two lines possessing many economic characters in common, but differing as much as possible superficially. The results support the assumption. Present work in Minnesota consists of crossing no less than sixteen breeds, but as boars of several breeds are allowed to mate indiscriminately with the sows, no attempt is being made to assess the proportions of different breeds represented in the crosses. The progeny are being selected for economically important characters to produce a commercial pig; the system of random breeding will be stopped when a desirable type is achieved and fixed by inbreeding.

In Montana a cross of Landrace and Hampshire (Wessex Saddleback) has been used to produce the Montana No. 1, and a cross of Landrace and Berkshire has produced the Maryland No. 1.

At the Beltsville Research Centre, two new breeds are recognized under the names of Beltsville No. 1 and Beltsville No. 2, being respectively a cross of Landrace and Poland China and a four-way cross of Large White, Landrace, Duroc and Hampshire. A reciprocal

recurrent selection programme has now been set up at Beltsville using their three best-combining lines. These are Landrace × Large Black, Landrace × Poland China, and Landrace alone. They are being mated in all possible combinations and a selection will be made of the best progeny for development as a new breed. At the same time another new breed will be produced by crossing the Large White, Hampshire and Poland China with the idea that the two new breeds, when stabilized, can be crossed to take advantage of hybrid vigour and produce a commercially valuable animal.

The use of these inbred lines for crossing purposes has demonstrated repeatedly that hybrid vigour is important in pigs. Extensive study indicates that it increases appetite, accelerates growth, and improves efficiency of food utilization. Even when restricted to the same level of feed intake as parent stock, the cross-bred pigs gain faster and more economically than the parent lines.

At Beltsville, also, a programme is being set up to establish high- and low-fat lines within herds of pure-bred Large White and Duroc pigs. The progeny will be fed out to market weight and the backfat measurements of the live animals will be taken at 150, 175, 200 and 225 lb., one of which measurements will be selected as representative. Using this backfat measurement, lines of pigs will be selected within breeds for thick and thin backfat for perhaps three generations. Assuming that one line will have thicker backfat than the market requires and that another will be too lean, crosses of the high- and low-fat lines will be made within the breeds or between the two breeds.

Poultry

Some twenty-seven experiment stations are actively engaged in a national project for the improvement of poultry by breeding. About 100 inbred lines have been developed since the middle 1920s and work is now in progress in crossing these lines. No outstandingly favourable results have been obtained by combinations of inbred lines for table-poultry production. Commercial hybrids account for about 10 per cent of the laying flocks, but they show no marked superiority over the best standard-bred or cross-bred fowls. Some resistance to various forms of lymphomatosis has been developed by certain inbred lines of White Leghorns, but there is no evidence that these lines transmit their resistance to their offspring when crossed with other lines or breeds. There is some evidence that shell quality can be improved and, in consequence, egg breakage reduced, by selective breeding. In California, mutations have been induced by irradiation, but the work has so far not progressed much beyond the stage of weeding out undesirables. A new broiler-testing station in Georgia has just completed its first test. There is no marked advantage of hybrids over pure-bred birds; the average of all birds in this first test shows that, at 10 weeks old, broilers could be sold at an average of 3.61 lb.

in weight with a food consumption of 2.55 lb. per lb. of bird. In Kansas it has been shown that there is a correlation between fast feathering and fast growth. Fast growth has a lower heritability than fast feathering, but it appears that selection for fast feathering would almost certainly result in faster growth as well as more efficient production, through better food conversion, and more top-grade carcasses.

The Beltsville White Turkey now accounts for about 25-30 per cent of the total turkey crop. It retains its position because of its high reproductive capacity—high fertility in the male and high egg production. With Broad-breasted Bronze Turkeys, effective mating is a serious problem and artificial insemination has to be practised purely as a mechanical device and not, as in cattle, as a means of disseminating valuable genetic properties. It is found, however, that artificial insemination gives about 80-85 per cent fertility compared with 60-65 per cent by natural mating. Inbreeding and cross-breeding of turkeys are only in their early stages, although one commercial concern is marketing a four-way cross of inbred lines, claiming high fertility and hatchability.

Although it can hardly be called breeding, an interesting discovery is that of parthenogenetic reproduction in Beltsville turkeys. Certain strains of the Beltsville White Turkeys produce eggs of which 20 per cent show embryonic development without fertilization. One parthenogenetic embryo actually reached the point of hatching, but did not survive. At the moment there is no apparent application of this discovery; since the parthenogenetic poults, if they survived, would all be male, it is difficult to see where one would go from there!

Labour-saving Methods in Row-crop Cultivation

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ALL ROOT CROPS make great demands on labour in the spring, particularly those where a regular pattern of plants along the row is desired, as this calls for careful and accurate work by the hoeman. Considerable effort is being made to reduce the labour required and, since the war, some progress has been made in this direction. As the work is organized and financed mainly by the Sugar Beet Research and Education Committee of the Ministry, most of the research has naturally been done with sugar beet, but the results apply equally well to the related crops of mangolds and fodder beet.

The difficulty with such crops lies almost entirely with the seed. It is well known that this is really a fruit containing two, three and sometimes four seeds, which give rise to two or more plants. These plants have to be disentangled at the time of singling, an operation which absorbs far more time than the actual job of leaving the plants the right distance apart in the row. If it were possible to put one seed every 10-12 inches along the row; if that seed could be relied upon to grow and produce a single plant; if the plant could be protected from pests and diseases; and if weeds could be easily and cheaply controlled; then the problem of the peak labour demand in spring would be solved. Until this can be done, some saving in labour will result if the hoeman is presented with a braird free from weeds and containing a high proportion of single plants well spaced out along the row. Moreover, such a braird will be easier to single mechanically. Research work is therefore mainly directed towards obtaining seed with a good field germination and single-plant production, and the development of suitable machinery to place single seeds at regular intervals along the row. Progress has been made in the control of fungus and insect pests which kill the young plants, and an easy and cheap method of chemical weed control is being sought. Machines are also being developed that will thin a spaced braird to leave more single plants at approximately the correct position in the row.

In this article seed and seed rates refer only to sugar beet. The conclusion deals with the possibilities of applying the principles outlined to other root crops.

Seed Structure

If the seed of sugar beet and allied crops contained one true seed which could be relied upon to grow under normal field conditions, economies in labour at singling time would be easy. Plant breeders are fully aware of the problem and are trying to breed commercial strains of sugar beet seed which is either mono- or double-germ.

Progress has already been made, and it is possible that before very long such seed will be available commercially. Theoretically, mono-germ is the most desirable, but while the field germination of the seed is low, the risk of using mono-germ seed is too great and double-germ is safer. This means that the majority of the seed will give rise to no more than two plants, but that some will produce only one. Double-germ seed which has been tested at Sprowston has given the following results:

	Seed Type	Time to Single	Plant Population
		per cent	*per cent*
1952	Ordinary Natural	100	100
	Double-Germ Natural ...	91	102
	Significant difference ...	6.6	3
1953	Ordinary Natural	100	100
	Double-Germ Natural ...	95	104
	Significant difference ...	5.3	4

The most interesting feature of these results is that in both years the use of double-germ natural seed gave quicker singling—significantly so in 1952—without a loss of plant population. This saving is almost as much as is obtained from rubbed and graded seed.

Rubbed and Graded Seed

The need to simplify the beet seed has long been recognized. The first attempt was to soak the seed in sulphuric acid, but this was a tedious and rather dangerous process. The Americans next turned their attention to mechanical treatment, first by producing segmented seed and later a rubbed and graded type. Rubbed seed has been available in this country for five or six years and the demand is increasing each year. The natural seed is rubbed between a hard rubber pad and a revolving carborundum wheel, cleaned and carefully graded to 7-11/64ths of an inch. This is the commercial grade.

The effect of rubbing the seed is to make it a more uniform size—an advantage when used in precision drills. It increases the number of seeds producing single plants, but reduces slightly the germination as can be seen from the following table:

Year	Germination		Singles	
	Natural	Rubbed	Natural	Rubbed
	per cent	*per cent*	*per cent*	*per cent*
1952	79	73	34	56
1953	75	58	33	56
1954	68	58	44	52

Within the commercial grade of 7-11/64ths in. seed, there are all grades, e.g., 7-8; 8-9, etc. An examination of the different grades shows that the smaller the grade, the lower the germination, but the greater the number of seeds producing single plants.

The appropriate grade for commercial use is therefore a compromise between a high germination and a large proportion of "clusters" producing single plants. Experimental work with different grades of seed is continuing and it is possible that alterations will be made. It was hoped at one time that the smaller 7-9/64ths in. grade would prove suitable, but it is now more likely that a grade intermediate between 7 and 11/64ths in. will be selected.

Comparison of Natural Seed with Commercial Rubbed Seed

In co-operation with the British Sugar Corporation, a series of trials was carried out by the Norfolk Agricultural Station to compare the natural seed with the commercial rubbed seed. Plots of both types were drilled at seed rates designed to sow equal numbers of seed per acre, the men were timed singling the plots, and plant populations counted. Yields were not taken except at Sprowston. The mean results of all the trials were:

Seed	Seed Rate	Time to Single		Plant Population
		Per Acre	Per 1,000 Plants Left	
	lb.	*per cent*	*per cent*	
Natural ...	15.0	100	100	25,100
Rubbed ...	10.7	91	93	24,600

The use of rubbed seed enabled a saving of 9 per cent to be made in the time required to single an acre of roots. If, for example, it takes a hoeman 20 hours to single an acre when natural seed is used, this is reduced to a little over 18 hours when rubbed seed is used. This substantial saving was obtained without any undue loss of plant. The small rubbed seed (7-9/64ths in.) resulted in a saving of 20 per cent compared with natural seed, but there was a loss of over 2,000 beet per acre. Such a loss becomes important in the 20,000 to 23,000 range of plant populations, as the compensation in root weight which occurs is not sufficient to make up for the loss of plant.

This saving in singling time was brought about, in part, by a reduction in plant population, as is shown in the table, but more important still is the thinner braird and the greater number of single plants in the braird. A stand of all singles is desirable, but not altogether

necessary: as Rayns [1] has stated, *all that is really needed is a lone plant standing somewhere within an inch or two of the "correct" spacing determined for the crop.* In the trials at Sprowston, the commercial grade of rubbed seed has never shown a reduced yield.

Drills

Modern root drills are designed to pick up one seed at a time and to place it singly in the row at fixed distances apart. Theoretically, it should be possible to place one seed in exactly the right place, so that little labour is required to single. Unfortunately this theoretical spacing is not yet possible in practice because some seed fails to grow under normal field conditions, and if it does germinate, it is liable to attack from fungus and insect pests. The precision drill is therefore designed to place the seed singly, but at narrow distances along the row, so that the hoeman can compensate for gaps in the braird.

In trials at Sprowston it has rarely been possible to show any saving in singling time from the use of precision drills, although plant counts on the braird have shown a better distribution. This is because no matter how well the plants are spaced, the hoeman has to remove weeds growing around the plant, and this requires as much time as removing surplus plants. Thus, only with exceptionally clean brairds is it possible to obtain the full benefits from a precision drill. In 1953, with a particularly weed-free braird, a saving of 14 per cent was obtained when compared with a standard cup-feed drill, sowing approximately the same seed rate.

The use of such drills for sugar beet has led to lower seed rates, the most usual being 7-10 lb. an acre, according to the time of drilling and the seedbed conditions. Many farmers are using less—even as little as 3 lb. an acre. By so doing, singling time is reduced, but there is always a risk that plant populations will fall to a dangerously low level. If low seed rates are used, it is essential to obtain good field germination. While this depends largely on weather and seedbed conditions, drills can have some influence too. Regular depth of seeding, and good consolidation behind the drill both influence plant establishment, and rear rollers mounted behind each coulter have become a standard fitting on most types of modern drill. The following figures show that in trials at Sprowston [2] the "Squirrel Cage" was an improvement on the solid type of rear roller as judged by plant establishment.

	Squirrel Cage plants per 100 in.	Rear Rollers plants per 100 in.
1952 ...	94.2	88.6
1953 ...	33.1	24.8

In 1952, plant establishment behind the Squirrel Cage was 6 per cent better than behind rear rollers and it was better by 17 per cent in 1953, a year of very poor germination of the grade of seed used. The improvement in plant establishment is probably because good soil consolidation is obtained without capping of the soil immediately over the beet seed.

The type of coulter has also been shown to affect plant emergence, probably because the best type deposits the seed at a more uniform depth and into the moist soil. Regular depth of seeding has so far received very little attention in this country but work in Germany has shown the importance of an even depth of seeding.

These results suggest that plant establishment can be improved. Combined with spacing drills this can lead to the safe use of lower seed rates—an important factor in saving labour.

Control of Pests and Diseases

If every seed sown is to grow, and if every plant is to survive until hoeing, full advantage must be taken of all chemicals available for the control of pests and diseases. In a recent article Jones and Humphries [3] discuss the value of mercurial compounds and γ-benzene hexachloride as deterrents against soil pests which attack sugar beet. They state that in their experiments the combined mercury γ-BHC seed dressing gave the best pre-singling stand of plants. Most of the improvement was attributable to the organic mercury rather than to the γ-BHC, but where pest attacks occurred the γ-BHC gave marked improvements in the stand. Wireworms appeared to be the chief pest controlled; control of pygmy mangold beetle was only partial. This suggests that where an attack of wireworm is anticipated, the seed should be given a dressing containing γ-BHC. Occasionally some damage has been reported to the growing beet but the authors claim that a dressing containing 40 per cent is usually safe. The cost of having the seed dressed is relatively small and should become a routine precaution when low seed rates are used or wide seed spacing adopted.

Gates and Hull [4] have obtained increased seedling emergence by treating the seed with panogen, thiram or ethyl mercury phosphate. These chemicals control *Phoma betae*, usually the predominant pathogen attacking beet seedlings in the field and one of the causes of Black Leg. This disease is usually most severe when seedlings grow slowly—not an uncommon event in many springs, particularly as today drilling tends to become earlier. All sugar beet seed in Eire is dressed with ethyl mercury phosphate by the Irish Sugar Company before distribution to growers, and they claim that no recorded case of *Phoma betae* has occurred since this dressing was introduced in 1952.

The research work outlined above is aimed at producing better brairds of root crops in order to assist the hoeman to accomplish more in the time available without increased effort on his part. The object has been to produce seed, a large proportion of which will give rise to single plants; to place these seeds at regular spaced distances along the row; to improve the field germination and protect them from pests and diseases. This would entail working with lower seed rates, an advantage which would be lost if a thick growth of weeds occurred in the row. It is of utmost importance, therefore, to control weeds in the row.

Weed Control

Most good farmers make a practice of killing as many weeds as they can before drilling; some do this work by means of harrows and weeders after the beet have brairded. Recently, work on the chemical control of weeds in sugar beet has been started and although this has consisted mainly of screening chemicals for use both as pre- and post-emergence sprays, some useful and interesting information has already been obtained [5 and 6].

The most successful post-emergence sprays have been nitrate of soda and salt—both chemicals used as fertilizers for beet and allied crops. These have been applied at the rate of $2\frac{1}{2}$-3 cwt., dissolved in 100 gal. of water per acre plus one gallon of wetter. The sprays have been successful against most weeds* other than fat hen (*Chenopodium album*) and orache (*Atriplex patula*), provided they were not more than 3-4 in. high (rosettes 2-3 in. across) when sprayed. If the weeds are bigger, the sprays merely defoliate the plant without killing it completely. Little damage is caused to the beet if they are in the four-true-leaf stage when sprayed.

One difficulty in using this spray is that of dissolving such a large quantity of nitrate of soda or salt in water, and for this reason the former is preferable as it dissolves more readily. It is, however, more expensive. Mixtures of the two are equally effective and have the advantage of cheapening the spray. Unfortunately, because of the quantity of spray which has to be applied, a high-volume sprayer is required. The total quantity can however be much reduced if the sprayer is adapted to spray a band—say 6 in. wide—over the row of beet, leaving weeds between the rows to be dealt with by the hoes in the usual way.

These sprays have been used on a field scale in Norfolk when thick weed growth had smothered the rows of beet and under these conditions they have certainly proved beneficial. As yet, no accurate measure has been made of the time saved in singling.

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*Susceptible weeds include: black bindweed, scarlet pimpernel, shepherd's purse, willow weed, fumitory, poppy, bugloss, spurrey, chickweed, knotgrass, speedwells, mayweeds, charlock and wild radish.

Pre-emergence sprays have been less successful, mainly because they each kill a limited range of weed species and because they tend to damage the beet more. They react differently on various soil types and results so far obtained suggest that none of the chemicals tested are reliable enough for general use as pre-emergence herbicides.

Of the many chemicals tested, the most successful has been IPC (isopropyl phenyl carbamate) applied as an aqueous suspension at 4 lb. per acre and worked into the seedbed before drilling. At this rate it has shown considerable promise against wild oat, chickweed and annual meadow grass but some temporary check to the growth of the crop must be expected.

Mechanical Thinning

For many years experiments have centred around labour-saving by mechanical means. Early attempts were by means of cross-blocking, which was first undertaken at Sprowston [7] as long ago as 1932. Cross-blocking consists of hoeing across the rows of plants at right angles to the direction of drilling. The early trials were done on brairds from 20 lb. of natural seed per acre sown with a cup-feed drill. More recently, trials have been made using rubbed seed in a precision drill.

To cross-block satisfactorily a level seedbed is essential and it is necessary to have a full plant, so that every "station" left by the hoes contains at least one plant. If to obtain this, the hoes have to be set wide apart, there is nothing to gain from cross-blocking because as much time is required to single the bunches as is necessary to single a continuous row of beet. Therefore, close setting of the hoes is necessary, and this can only be done on regular brairds. Where cross-blocking can be carried out in a satisfactory manner a considerable saving in singling time can be achieved, although this is always accompanied by a loss of plant. Typical results from a trial carried out at Sprowston in 1951 are given below:

Method	Bunches after Cross-blocking	Time to Single	Time to Second	Total Time	Number of Plants
		per cent	*per cent*	*per cent*	*per acre*
Singled by hand ...	—	100	100	100	29,600
Cross-blocked	30,200	77	89	80	25,400

From these figures it will be seen that a 20 per cent saving in singling time was recorded but with a loss of over 4,000 plants per acre. Part of this saving may have been due to the improved hand-hoeing conditions, the result of cultivations across the rows, but part was undoubtedly due to reduced plant populations.

Cross-blocking has never become an established practice in this country, probably because of the exacting conditions necessary for its success. Today it is used only when a farmer is in difficulty with his singling when, by putting the hoes across the rows, he is less likely to suffer from decreased yields.

Interest, largely stimulated in the U.S.A., has recently returned to so-called "down-the-row thinning" and a number of American with a few English machines are available. The testing of these machines under our conditions is in the early stages and reports are few. There are two schools of thought on the way in which the machines should be used. The first is that they should single the crop, thereby doing away entirely with hand labour, while the second is a sort of half-way house, in that the machines should be used to bunch a spaced braird, the necessary singling to be finished by hand.

Use of the machines is based on a mathematical calculation. Braird counts have first to be made, and then according to the number of plant "stations" required, certain cutting heads or combinations of heads are used. Theoretically, this should leave the desired plant population. To do this it may be necessary to go through the crop three or four times, increasing proportionally each time the amount of ground cut, and decreasing the size of bunch left.

The opinion at Sprowston is that it is not desirable to go through the crop more than twice; anything which cannot be accomplished in these two operations should be finished by hand. The first time through (using a weeder-head) is regarded as a thinning operation in an attempt to remove weeds and increase the number of single plants standing in the braird. The second is a bunching operation to leave plants with a regular pattern along the row. The advantages of a well-spaced braird containing a high proportion of singles and free from weeds is therefore obvious.

Experimental work with the "Eversman" type of thinner at Sprowston has given substantial savings in labour, as can be seen in the next table which shows the best results from the 1954 trials.

Treatment	Time to Single	Plant Populations	
	percentage of (a)	*per acre*	*percentage of (a)*
(*a*) Hand Singled	100	30,300	100
(*b*) With Weeder Head—			
$\frac{3}{4}$″ *bunch:* $\frac{3}{4}$″ *gap* ...	58	24,400	81
$1\frac{1}{2}$″ *bunch:* $1\frac{1}{2}$″ *gap* ...	64	28,200	93
(*c*) Without Weeder Head—			
$\frac{3}{4}$″ *bunch:* $\frac{3}{4}$″ *gap* ...	73	28,700	95
$1\frac{1}{2}$″ *bunch:* $1\frac{1}{2}$″ *gap* ...	80	29,600	98

Thus, substantial savings were obtained without a considerable loss of plants per acre. The use of the weeder head reduced the number of doubles in the braird, but did not increase the number of singles, because some of the original singles were also removed; in all cases it reduced the plant population. In general, it appears that the type of head which leaves a small bunch and a small gap is the most successful, but when pre-thinning is done the head which follows must leave a larger bunch and gap, if serious loss of plant is to be avoided.

Effects of Doubles and Irregular Spacing

The use of mechanical thinning is likely to lead to a more irregular plant, probably containing a larger number of doubles than is considered desirable in hand-singled work. The effects of doubles and irregular spacing have been examined at Sprowston. Stands containing up to 25 per cent of doubles have not given lower yields, but have materially increased the labour required to harvest the crop by hand. This can be clearly seen in the following table which summarizes the results of three years' trials:

Proportion of Doubles	Beet Yield	Sugar Content	Time to Pull and Knock	Time to Top	Man-hours per Ton of Beet
per cent	*tons per ac.*	*per cent*	*per cent*	*per cent*	*per cent*
—	16.6	17.5	100	100	100
25	16.7	17.4	110	117	115
50	16.2	17.5	117	132	130
75	16.1	17.6	121	147	139
100	15.5	17.6	128	154	156

Work on irregular spacing, provided plant populations are maintained, suggests that gaps of up to 2 ft. do not reduce yields but that gaps greater than this do.

Although doubles and irregular spacing have no effect on the yield, they do of course interfere with efficient harvesting by machines.

Applying Results to Other Root Crops

As previously mentioned, most of the efforts to reduce labour have been made with sugar beet, but many of the results obtained apply equally well to other root crops.

Broadly speaking these other crops can be divided into two groups—the chenopods and the brassicas. The same advantages will result with mangolds and fodder beet as with sugar beet. With cross-blocking and mechanical thinning greater success can be expected, because with the

coarser-growing roots a less regular plant is required, and as they are still mainly harvested by hand the efficiency of harvesting machinery does not arise. As the experience of thinners increases so will hand labour be reduced. It is likely that with a spaced braird the machines will remove sufficient of the surplus plants to eliminate hand work other than for the removal of weeds which cannot be killed by spraying with either nitrate of soda or salt.

Brassicas present rather a different problem because of the nature of the seed. There seems to be no reason, however, why drills should not be adapted to sow this type of seed at least thinner and more regularly than is done at present. This is probably a safer practice now that the recently introduced seed-dressings control flea-beetle attack at least until the crop is well established.

Kale is often grown successfully without singling. In any case, the need for single plants at regular distances in the row is not essential, and cross-blocking with existing row-crop equipment can be more successful with this crop than with any other. With the introduction of the new thinning machinery a sufficiently spaced braird can be obtained without any hand labour at all. Weed control is often not necessary because of the smothering effect of the kale, but the crop can be successfully sprayed with sulphuric acid if desired.

Swedes and turnips are both usually harvested by hand and regularity of spacing and doubles in the row are not therefore so important. These crops could also be sown more sparsely and thinned mechanically, thus saving all but perhaps one hand hoeing to remove weeds not dealt with by the thinners.

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The Ditton Laboratory

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THE DITTON LABORATORY is one of the three main laboratories of the Food Investigation Organization, the other two being the Low Temperature Research Station, Cambridge, and the Torry Research Station, Aberdeen. The Food Investigation Organization is one of fourteen research establishments of the D.S.I.R. and undertakes research on the properties and behaviour of foodstuffs and on methods of handling, transporting, storing and processing them. At the Torry Research Station the work is concerned with the preservation of fish from the time it is taken from the sea until it is consumed, and with the utilization of surplus fish and fish waste. The work at the Low Temperature Research Station, Cambridge, the parent laboratory, is concerned with the biochemistry and biophysics of foodstuffs in general and with the preservation of meat and eggs. At Ditton attention is mainly directed to the storage and transport of fresh fruits and vegetables.

Original Work of the Laboratory

The Ditton Laboratory was built in 1929 to house a model ship's hold which was required for research work on methods of cooling ships' cargoes and on other aspects of applied refrigeration. The laboratory also provided the facilities for work which had been started at Cambridge on the gas storage of apples and pears, to be carried out on a larger scale and brought to the stage of commercial development.

The site at Ditton was chosen so that close contact could be maintained with the fruit-growing industry of Kent, and so that the work on preservation could be linked with the work on fruit growing which is done at the East Malling Research Station.

Between 1930 and 1939 the conditions for the gas storage of most varieties of apples and pears were worked out, and gas storage was established as a standard method of storing English apples and pears.

During the same period comparison was made of the relative merits of cooling ships' cargoes by "grids" within the holds and by a forced air circulation and external coolers. The effects of dunnage and methods of stacking on rates of cooling and temperature distribution were determined, and measurements were made of the production of heat and carbon dioxide by the fruit. The results obtained led to far-reaching advances in the design of refrigerated ships, in the design of the fruit pre-cooling stations which were being built in South Africa, Australia and New Zealand, and also in the construction of smaller cold stores and gas stores.

Post-War Developments

During the war years the work of the laboratory was interrupted. The experimental hold was used for fundamental work on problems associated with the de-icing of aircraft. Attention was also given to the preservation of fruit by drying.

After the war work was started again on the handling and preservation of fresh fruit and vegetables. There were many new problems. For example, potatoes which had formed an important source of home-grown food were still largely stored in clamps, the emptying of which is slow and often interrupted by unfavourable weather. Attention was therefore directed to the possibility of storing potatoes in barns.

New methods of marketing vegetables and soft fruit had been developed in America and needed to be studied under English conditions. There had also been claims from America that the use of activated charcoal filters in apple stores reduced the incidence of certain physiological disorders. These claims had to be tested.

It also became apparent that Cox's Orange Pippin apples held in storage seemed to be more liable to lenticel rotting than they had been before the war. This gave rise to grave concern because the increased planting of Cox's Orange Pippin trees was resulting in an increasing production; consequently the crop needed to be spread over a longer marketing period.

New methods of constructing stores had been developed, and the time had arrived for an extensive comparison of the efficiency of various types of construction. Methods of chemical analysis had been developed which allowed a more detailed examination of the composition of fruits. By the application of these methods it was hoped to gain fundamental knowledge which might make further advances possible.

Work was done on all these problems as staff became available, the aim being, first, to discover the best conditions for the storage of apples, pears and vegetables and for the handling and transport of the very perishable soft fruits and vegetables, and, second, to determine the methods whereby these conditions might be obtained in practice. In this way, the storage life of home-grown fruit can be extended, the quality of the fruits and vegetables reaching the consumer can be improved, and the wastage reduced.

The work is made difficult by the very great variety of fruits and vegetables, all of which need separate consideration, and by the shortness of the season in which any particular fruit or vegetable is available for experiments. It is also made difficult by the large scale on which certain experiments need to be made and the problem of finding labour to handle large bulks of material. Sometimes this latter difficulty has been overcome by obtaining the help and co-operation of interested growers and by using commercial stores and commercial consignments.

Current Research

Some of the more important investigations now being made concern the following subjects:

The gas storage of apples and pears. A continual effort is being made to find improved conditions for the storage of the main varieties of apples and pears by means of storage trials carried out at different temperatures and gas conditions. The effect of changing conditions during the storage period, of removing certain volatile products from the air of the store by filters or by chemical methods, of storage in low oxygen concentrations combined with the continuous removal of carbon dioxide, and of the addition of volatiles are all being investigated. Conditions for the storage of new varieties, and the factors contributing to the incidence of such physiological troubles as "scald" and low temperature breakdown, are also being studied.

The storage and marketing of soft fruits and vegetables. Surveys of the amount of wastage in marketing soft fruits and vegetables are being carried out, and methods of reducing wastage being developed. This work is being done jointly with the Ministry of Agriculture, Fisheries and Food. Particular attention is being paid to the effects of maturity at the time of picking, to pre-cooling, and to the use of dry ice to maintain a moderate concentration of carbon dioxide around the fruit.

The storage of potatoes. The conditions for the successful storage of potatoes in bulk have been determined. Work is in progress on methods of reducing sprouting by the use of volatile inhibitors which can be introduced into stacks of potatoes in the spring. The reasons for varietal differences in the length of the dormant period and in the rate of sprout growth are being investigated. Methods of assessing "quality" in potatoes are being developed.

The effect of orchard factors on the composition and storage disorders of fruits. The extent to which apples grown under different conditions differ in composition in respect of nitrogen, potassium, magnesium, calcium, etc., and also differ in storage behaviour is being considered with a view to discovering ways in which orchard conditions can be modified to give fruit with a long potential storage life. This work is being done in co-operation with East Malling Research Station, and use is being made of fruit from the Station's trial plots.

Lenticel rotting of Cox's Orange Pippin apples. Lenticel rotting of Cox's apples held in store has been severe in recent years. The conditions under which the fungi (*Glocosporium spp.*) responsible for this rotting are found in the orchard; the ways in which the spores reach the fruit and cause rots; and the factors affecting the development of rots are being studied with a view to finding control measures.

The biochemistry of fruits. New methods of analysis have increased our knowledge of the composition of plant tissues and indicated the presence of many compounds previously unknown to occur in plants. Further

knowledge about the composition of fruits may give indications of the nature of the ripening changes and the way in which they can be controlled; it may also provide a means of predicting storage behaviour.

The volatile compounds produced by apples have been identified, and the amounts present in the storage atmosphere have been estimated so that their effect on storage behaviour can be determined. The nature of the waxy coating of fruit is also being determined in connection with experiments on the incidence of scald.

The construction and operation of cold stores and gas stores. Surveys are being made of commercial cold stores and gas stores. Their efficiency in respect of heat and gas leakage is being assessed so that the merits of the various types of construction can be compared. Methods of modifying existing stores so that water loss from the stored produce can be reduced are being tried. The performance of refrigerating plants has been measured, and ways of running them more efficiently have been suggested. These tests have been made possible by the co-operation of growers.

Laboratory tests are being carried out on the effect of the temperature and surface area of a cooler on the conditions within stores, and the efficiency of heat transfer of coolers of different design is being determined.

Experiments are also in progress on improving the efficiency of "scrubbing" units which are necessary for removing the excess carbon dioxide from stores in which reduced oxygen concentrations have to be maintained.

Advisory Work

A general account of work in progress is given each year in the *Annual Report of the Food Investigation Organization.* The work of the laboratory is also published in the form of Special Reports, Advisory Notes, and papers in scientific and trade journals.

The laboratory has always kept in close touch with growers and advised them on problems of storage. However, so many growers throughout the country now own cold and gas stores that it is no longer possible to maintain the close contacts which existed in the 1930s when gas stores were first being built. Further, growers who go to officers of the National Agricultural Advisory Service for advice on growing fruit also ask for advice on storage problems. In consequence, steps have been taken to develop close liaison between the laboratory and the N.A.A.S. Efforts are being made to keep the N.A.A.S. specialist officers informed of the progress of work undertaken at Ditton and of the advice given in reply to enquiries received directly by the laboratory. Members of the N.A.A.S. have also kept Ditton informed of the enquiries they have received and of any special troubles arising in their areas.

Reviews and Abstracts

Animal Breeding

Some sixteen studies published in the recent *Proceedings of the British Society of Animal Production* are an interesting sample of current research in this country which can either be directly applied to, or has positive implications for, livestock production.

Breeding Techniques

Of the papers bearing on animal breeding, there are three which, by suggesting improvements in techniques, set out to make better use of existing data and labour. One of these [1] discusses problems in weighing grazing cattle and sheep. At first sight, nothing seems simpler—given a suitable weighbridge—but in fact the time of day at weighing affects the amount of "fill" in the gut, and this in turn has an appreciable effect on the apparent liveweight. Differing periods of fasting prior to weighing and choice of regular time of day—in terms of the sun, not of the clock—facilitate more accurate assessments of liveweight gain than are otherwise possible. Another paper [2] describes the calculation of a "Relative Genetic Value" which, although it has recently changed its name, is one of the methods used to assess the worth of bulls at M.M.B. artificial insemination centres. The "value" takes into consideration the average yield of the bull's daughters and relates this to yields of contemporaries, to herd and to breed average yields, to the heritability of herd average yields, and to the number of daughters of the bull on test. Hopes are high that this "value" will improve bull selection, and there is of course no reason why, under certain conditions, it could not be adapted for bulls in natural service.

The problem of accuracy versus speed of assessment of production potential—in this case the laying propensities of Rhode Island Red hens—is the subject of a third paper [3]. In a particular breeding flock the choice lay between selection on the basis of a partial record of egg production, i.e., from first egg to the end of November, or on a full year's record. In terms of genetic gain in egg production per year, the partial record had an advantage over the full record in the ratio of 1.5 : 1.

Operational Research

Four further papers come under the general heading of "operational research"—that is to say, investigations into current breeding practice or aspects of it. Conclusions from these investigations may well help

(See pp. 188-197)

A braird from natural seed. The plants are thick in the row, and time will be lost separating one plant from another.

A well-spaced braird from rubbed seed. With such a braird, easy and quick singling is possible as many plants stand singly in the row.

PLATE I.

The plot in the foreground has been sprayed with nitrate of soda; middle plot unsprayed.

A cross-blocked braird. Some of the bunches contain too many plants and time will be lost separating them.

PLATE II.

Cross-blocking a 28-acre field of sugar beet at Sprowston.

Close-up of cross-blocking hoes.

PLATE III.

A braird before mechanical thinning.

The same braird after once through with the thinner.

The thinner has now been through for the second time and the braird can be singled easily by hand.

PLATE IV.

in formulating future plans or in assessing past breeding progress. For example [4], a number of inbred heifers got by father × daughter matings were found in recent volumes of the British Friesian Herd Book. Comparison of 80 of these with their outbred sisters showed that the inbreeding had had no effect on age at first calving nor on fat percentage, but that there had been a decline in milk yield equivalent to 0.32 per cent for every 1 per cent increase in the inbreeding coefficient.

An old problem which gets a new airing [5] asks the question: "Should animals be selected under environmental conditions similar to those where they are to be used; or should the environment be optimum to reveal the genetic capabilities of the animals?" An answer is sought from milk yields of 8,500 daughters of 123 bulls used at artificial insemination centres in Denmark. The herds in which the cows were milking were divided according to average yield, into "poor", "medium" and "good". The yields of the daughters of the 123 bulls were compared with yields of contemporary heifers by other bulls in the same herds. The order of merit of the bulls was intrinsically the same when based on tests in each of the three groups of herds but since differences between bulls showed up more in good than in poor herds, selection was easier in good herds.

Another paper [6] reports the average size and average duration of registered flocks of 11 lowland breeds of sheep. Forty per cent of the 1,381 flocks involved were less than 4 years old or comprised less than 50 ewes. However, flocks near the "native" region of their breed, and flocks producing large numbers of rams for use by other pedigree breeders, were on average both bigger and older than other flocks registered in the same flock book. It is concluded that, in the many small flocks of short duration, little seems possible by way of deliberate genetic advance for many economic characters of low heritability, but that this is not necessarily true for the oldest and largest of the flocks in the breeds studied.

Finally in this group is a report of investigations on the vertebral column of the Welsh pig. [7] By an X-ray technique it was found that one of the two herds investigated consisted of pigs with nearly half a vertebra more, on average, than the pigs in the other herd. Since length is a desired trait in bacon pigs, and there appears to be a good correlation between body length and presacral vertebral number, a technique such as the one described could help to select pigs for length alone at an earlier age than may otherwise be possible.

Detailed Experiments

Lastly, four papers give results of specifically designed experiments. One such [8] has as its aim the shortening of the generation interval which would have advantages in selection, similar in kind to those achieved through use of partial versus full production records (see above). The experimental work was done on rabbits. By suitable injections and

surgical techniques it was found possible to produce young from the ova of immature does after transferring the ova to uteri of mature does. This makes possible three rabbit generations per year compared with a more normal two; a table is given showing the theoretically attainable number in farm livestock.

In a different vein are two experiments on feeding of several breeds of cattle [9] and of sheep [10] on similar feed levels in order to compare their relative efficiency of meat production. The cattle experiment (under the auspices of the N.A.A.S.) comprised various beef breeds and crosses and had a strong economic slant. The sheep experiment utilized six crossbred types common in Scotland (Halfbred, Greyface, and each of these crossed with Oxford and Suffolk). They did not differ significantly in their efficiency of food conversion. Greyfaces, though they took longer to finish, ate less per week. In this connection it is of interest that a paper published in the *Journal of Agricultural Science* [11] reports that three breeds of sheep—Blackface, Cheviot, and Wiltshire—reacted somewhat differently to four different environments—sheltered versus exposed environments combined with high versus low feed levels. Although the breeds did not change rank under the different treatments, Blackfaces grew relatively faster on the good plane of nutrition than the other two breeds.

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G.W.
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An Analysis of Data from the Danish Bull Progeny Testing Stations. I. JOHANSSON. *Zf. Tierzuchtg. w. Zuchtgsbiol.*, 1954, **63**, 105-26.

One hundred and seventy four Red Danish bulls were progeny tested in special stations. An intrastation analysis of contemporaries showed significant progeny group differences in milk and butterfat yield, butterfat percentage, body weight, calving age, calving date and service period. But, the author states, "there are strong indications, however, that part of the intrastation variance between simultaneously tested progeny groups is due to differences in the state of nutrition and body development at the time of calving". It is emphasized that efforts should be made to avoid such prior nutritional differences in progeny testing experiments. The data indicate that a good state of nutrition at calving enhances the yield of both milk and butterfat. Body weight at calving had more effect than calving age on the yield to 250 days during first lactation. Some animals with high yield lose weight during lactation, others show slight gains; whereas animals with low yield show marked gains in weight. It is also stressed that care must be taken lest daughters intended for testing are selected according to their dams' merit. There is some evidence that this may have occurred in respect of the progeny under consideration.

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H.P.D.

Recent Experimentation on the Nitrogenous Manuring of Grassland

Utilization of nitrogenous fertilizers on the grasslands of England and Wales was assessed by Boyd and Lessells [1]. The average amount of nitrogen applied to leys (longer than one year) in 1952 was 0.15 cwt. of nitrogen per acre, whilst permanent grass received only 0.07 cwt. per acre. Less than half the total grassland received nitrogenous fertilizer during any year. Experiments showed that the application of 0.25 cwt. of nitrogen per acre to grass for drying or silage caused an average increase in yield of 2-2.5 cwt. of starch equivalent per acre. Similar amounts of nitrogen applied to hay produced an additional 2.5 to 3.0 cwt. starch equivalent in dry areas, and 3.5 to 4.0 cwt. in wet areas. Although the average quantity of nitrogen used on grassland is small, it probably has a considerable potential for increasing production, and some of the recent experiments concerned with the application of nitrogen to grassland are summarized below.

Grassland Establishment

The value of applying a light dressing of nitrogen to the seedbed of a grass/clover sward was demonstrated by Woodhouse and Chamblee [2]. The application of 20 lb. of nitrogen per acre resulted in a better growth of both clover and grasses without appreciably altering the relative

proportion of grass/legume. A dressing of 80 lb. of nitrogen at seeding, although increasing the total yield of the mixture, resulted in a reduced percentage and a poorer growth of white clover. Presumably the light dressing provided nitrogen for the clover prior to nodule development, whilst the heavier dressing stimulated the growth of grasses to such an extent that the clover was suppressed.

Methods of Application

Several recent experiments have compared the relative effects of applying comparable rates of nitrogen in different forms. Walker *et al.* [3] applied equivalent amounts of nitrogen in the form of urea, nitrolime and sulphate of ammonia to a ryegrass/white clover sward. Comparable rates of nitrogen in different forms caused similar increases in the dry matter yields of herbage, and all the nitrogen applications increased the weight of grasses and decreased the yield of clover. This process was more marked with sulphate of ammonia than with either urea or nitrolime. The highest rate of sulphate of ammonia (0.6 cwt. nitrogen acre) resulted in 30 per cent less clover than any other treatment. Increasing the rate of nitrogen application raised the nitrogen percentage in grasses, but had no effect on the nitrogen content in clover or on the total nitrogen yield of the mixture. The form of nitrogen did not appear to influence the percentage or yield of nitrogen in either the grasses or clover. The results indicate that if nitrogen is applied to grassland and it is desirable to maintain clover production, the use of sulphate of ammonia should be avoided. It was considered that whilst the high production of grasses after the application of sulphate of ammonia may have caused the extra depression of clover, a contributory factor may have been a temporary reduction in the *p*H of the soil after application of this fertilizer. In particular, a lower *p*H might have adverse effects on the availability of the molybdenum required for nitrogen fixation by the legume. Finally, there appeared to be no difference in the efficiency of nitrogen uptake from the different forms of fertilizer.

It has been suggested that the application of nitrogenous fertilizers in the form of a foliar spray may be more effective than solid application (particularly in dry weather). Chesnin *et al.* [4] conducted experiments on several crops (including lucerne and bromegrass) to determine how much nitrogen could be applied as a spray without causing damage. The nitrogen was applied as urea, and 176 lb. of nitrogen per acre were sprayed on to bromegrass without causing any damage. However, the application of 20 lb. of nitrogen per acre to lucerne caused slight marginal scorch on the leaves. (The nitrogen was applied as a fine spray in a nearly saturated solution.) The burn increased as the amount of nitrogen rose from 40-60 lb. per acre; coarse sprays also increased the damage.

Low and Armitage [5] compared the relative effectiveness of solid versus liquid applications of nitrogen. Urea was the form of nitrogen used as it is highly soluble in water, and earlier experimentation had showed that this form of nitrogen caused less damage to clover than the

same concentration and amount of ammonium nitrate. Rates of 0, 10, 20 and 40 lb. of nitrogen were applied three times a year to a predominantly ryegrass/white clover sward. The methods of application were as fine crystals or as aqueous solutions (at 20 gal./acre), with and without a liquid spreader. Three days after application the sprays had caused scorching of the clovers; the damage was greatest at the highest nitrogen rates and was increased by the use of the liquid spreader. Grasses appeared to be only slightly damaged by the spray, and the solid form of nitrogen caused no visible damage to either grass or clover. During 1952 the differences in total herbage production or crude protein yield from the various methods of application were not significant, whilst in 1953 it appeared that the aqueous spray without the spreader produced the lowest yields of dry matter and crude protein. Increasing rates of nitrogen progressively decreased the clover percentage, but there was little difference in the amount of clover between application methods. A similar trial was conducted on a pure Italian ryegrass sward, and although yields increased with nitrogenous applications the method of application again had no significant effect. Periods of dry weather occurred during the experiments, but no advantage was derived from the aqueous sprays; on the other hand these sprays caused more damage to the clovers than solid applications.

The advisability of placing nitrogen in the soil close to the roots of grasses was studied by Russell *et al.* [6]. Nitrogen was applied either as a surface application of ammonium nitrate or injected at a depth of 5 in. as anhydrous ammonia. The applications were made to bromegrass in the autumn, and the rates varied from 0-240 lb. of nitrogen per acre. The subsequent spring growth was significantly greater from the normal applications than from the anhydrous ammonia.

Rates of Fertilizer Application

Walker *et al.* [3] applied various levels of nitrogen from 0 to 2.4 cwt. per acre to ryegrass/white clover swards cut for dried grass, hay and silage. The first 0.3 cwt. of nitrogen resulted in the greatest increase per unit of nitrogen, and produced 7 cwt. more dry matter than the non-fertilized swards. This yield was also somewhat higher than the treatments which received 0.6 cwt. of nitrogen. The nitrogen tended to increase the yields of grass and decreased the growth of clover. Between 0.3 and 0.6 cwt., the suppression of clover was apparently greater than the stimulus to the grass. The writers stated that, in earlier work, pure grass stands showed a linear response in yield to nitrogen applications. Presumably in this trial the increased growth of grass caused such a depression in the clover that the reduction in the supply of organic nitrogen was not offset by the applied mineral nitrogen.

Single applications of 0, 2 and 10 cwt. of "Nitro-Chalk" were applied to ryegrass/white clover and cocksfoot/white clover swards and to pure stands of ryegrass and cocksfoot by Ivins and Fernando [7]. Nitrogen increased the total dry matter yields and decreased the clover content.

Three silage cuts were taken after the fertilizer application, and the yields of all three cuts were increased by the 10 cwt. dressing. However, the 2 cwt. level only affected the first cut, and the succeeding second and third cuts yielded less than the swards which had received no nitrogen. Presumably there was no residual nitrogen from this low dressing, and the reduction in clover percentage was reflected in lower herbage production. It was concluded that the nitrogen contribution of the clover was less than 2 cwt. of "Nitro-Chalk". Attention was drawn to the high calcium:phosphate ratio (2.15:1.00) in the herbage which had received 10 cwt. of "Nitro-Chalk".

Wagner [8] applied differential dressings of nitrogen to pure stands of cocksfoot, tall fescue and white clover; the results were compared with the yields obtained from cocksfoot/white clover and tall fescue/white clover swards. Nitrogen increased the yield of grasses and decreased clover production in the pure stands. The grass/legume mixtures with no applied nitrogen produced as much dry matter as the pure grasses plus 160 lb. of nitrogen per acre. The most even production throughout the year was obtained from the mixtures of grass and clover. In a later paper the yields of protein from this experiment are discussed [9], and 160 lb. of nitrogen were again required to give the same protein production from the pure grass swards as from the grass/clover mixtures.

The maintenance of high herbage yields by the continued use of heavy dressings of nitrogenous fertilizers have been reported by Holmes and MacLusky [10]. Swards which had received between 15 and 30 cwt. of "Nitro-Chalk" per annum for 6 years still produced between 8,350 and 9,620 lb. of dry matter per acre. To maintain this production it was necessary to give adequate dressings of potash (300-500 lb. of K_2O per acre). In the absence of applied potash the yields were less than 6,000 lb. per acre. It was calculated that, on the basis of this experiment, clover was able to provide the equivalent of 100-200 lb. of nitrogen per acre.

Several of the above experiments showed marked decreases in the clover content after nitrogenous fertilizing, and presumably as the clover is reduced, additional mineral nitrogen is required to replace organic nitrogen. All the experiments involved cutting treatments, and generally the fertilizers were applied when both the clovers and grass were actively growing. Clover is relatively inactive during the early spring and late autumn, and the application of nitrogen to stimulate the growth of grasses during these periods (particularly if followed by grazing) would probably not have such a depressive effect on clover. This would enable the efficient utilization of both mineral and organic nitrogen.

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H.K.B.

Farm Management

The Role of Management

Increasing complexity of modern farming has focused attention on the farmer in his capacity as a manager. The farmer seeking guidance on the principles of sound farm management has not, however, been able to satisfy his curiosity by reference to any standard British work on the subject and has had to rely very largely on common sense and rule of thumb. The recent timely appearance of two publications discussing the role of management in present-day farming is therefore most welcome.

Both publications make it clear that the primary objective of the farmer—as a manager—is to obtain the highest possible profit over a period of years, without depleting the fertility of the land. The degree of success which he achieves in reaching this objective depends on his ability to make full and effective use of all the resources at his command. From this common ground the two authors develop the subject in rather different ways. Because good management is more an art than a science, and because there are so many variables, James Wyllie [1] is at pains not to circumscribe the farmer's actions with a set of rules and precepts which might be honoured more in the breach than in the observance. Professor Thomas [2], on the other hand, emphasizes that the art of management is likely to be most rewarding to those who practise it if they discipline their natural gifts and apply certain objective tests.

Factors which Influence Profit

Wyllie fully recognizes that farm records and accounts "provide one of the foundation stones of efficient and progressive management" but he is more concerned in this publication with the application of principles than with the minutiae. After discussing certain specific problems such as the choice of a farm and the management of labour, he deals in some detail with each of the different enterprises comprising an individual farm. In the section on milk production, for example, he discusses the influence on profit of such factors as milk yield per cow, feeding policy, seasonality of production, calving schedules and the need to minimize overhead costs per gallon of milk produced. In this, as in other sections, there are many useful comments regarding the variety of methods by which high profits may be achieved, and the whole book stresses the paramount importance of good technical knowledge and skill in managing a farm. Indeed, much of the book deals with the technical rather than the economic aspects of management, and may therefore appeal more to those who still maintain a healthy distrust of "the dismal science" of economics.

Professor Thomas assumes that technical competence is a prerequisite to efficient economic management. In considering the economic aspects of management, he directs attention in turn to:

(*a*) the level of output from the land;
(*b*) the management of capital and finance;
(*c*) the management of labour and equipment;
(*d*) the use of standards in management.

Under the first heading he reiterates Wyllie's statements about the importance of high output in order to spread farm overheads. This high output may be achieved by any, or a combination of, the following: high yields, highly intensive crops, additional subsidiary enterprises and more direct revenue-producing activities. Farmers are advised to carry out an annual "capital-budgeting" exercise, in order to estimate their capital requirements for the forthcoming year and, by estimating the return on new investments, to find the best avenue of investment in their farm business. Sources of farm credit are discussed, and a plea is entered on behalf of the much-maligned and poorly supported system of "chattel-mortgages". In the section on management of labour, some suggestions are made regarding the true economy of high wages. The human relationships between master and man are mentioned in passing, but the advantage of the "Come on, lads", over the "Go on, men" approach, referred to by Wyllie, is not considered. Finally, the use of efficiency standards and the desirability of good records for calculating such standards is discussed. "Systematic record keeping should be regarded as the essential discipline of sound business management."

Analysis of Accounts and Farm Businesses

In this connection, Professor Thomas acknowledges the valuable contribution which C. H. Blagburn of Reading University has made to the development of a fairly simple system of economic analysis of the farm business. This system has now been described in a publication by Blagburn himself [3]. His paper indicates how the main economic weaknesses may be diagnosed, so that advice can be concentrated on those aspects of management where there appears to be most scope for improvement. This system has been based on the fairly simple records normally found on farms.

Blagburn begins by measuring the general level of the output of the farm. This output is compared with the output of similar farms by means of a *system index* which "determines the relative intensity of the farming system as measured by the concentration of productive enterprises on the farm". In other words, this index shows whether a satisfactory output could be achieved with the existing system of farming under average management. If the system index is low, then some change in the cropping and livestock organization is indicated. If the system index is high, then the system of farming is satisfactory and the reason for any low output is probably low yields. Blagburn advocates the use of a *yield index* to compare yields with average results and points out that the combination of a high system index with a high yield index is normally associated with a high profit. But it is doubtful whether the yield index is worth calculating on many farms. A more easily understandable assessment may be made by comparing the farm's yield of crops, milk, eggs, etc., with average yields. Not only will this show whether the farm's general yields are high or low, but it will also show which enterprises have high yields and which low, and appropriate action can then be taken. Some subsidiary tests of efficiency are illustrated, such as utilized starch equivalent per acre, livestock output per acre of food, and milk per acre of feed.

Detection of Excessive Expenditure

If this preliminary examination of the farm output gives a satisfactory result, then any low profits must be due to excessive expenditure. Blagburn suggests three measures of expenditure which will help to indicate whether or not expenditure is reasonable. The first is fertilizer cost per acre. "This is one of the few items of expenditure where the objective should generally be an increased outlay per acre." The other two measures both relate to labour—labour per £100 output, and work units per man, the latter method being favoured.

The value of this type of systematic approach to management problems has been satisfactorily demonstrated on numerous farms up and down the country and Blagburn rounds off this booklet by showing how his approach might be used in examining a 140-acre dairy farm. In this instance, the conclusions drawn were that output should be increased by improving forage production, by expanding the subsidiary enterprise and by improving the income per cow.

Alternative Methods of Analysis

It should not, however, be thought that there is only one correct way of analysing a farm business. There are in fact several alternative methods, the common feature of which is the systematic, logical and objective approach which they make to the problem of the farm as a whole. One such alternative is set out in a recent publication by D. B. Wallace of Cambridge University [4] in which the author draws largely on experience gained in the eastern counties. This report shows how the weaknesses in a farm business may be highlighted with little more than the ordinary accounts that must be prepared for taxation purposes. It sets out certain "key-factors" which the farmer, or his accountant, might calculate and which act as "gauges" of the farm organization. The method is illustrated by reference to a 140-acre boulder-clay farm and the results interpreted.

Profit or farm income was the first key-factor used. The farmer concerned was only making £4 per acre compared with £11.6 per acre on the best-managed farms in the district. In view of the good crop yields and healthy livestock the farmer was puzzled that the result was not better. Further analysis showed that the farmer's net output per acre was low, and this was not due to crop yields or even his system, but to an inefficient livestock sector. His livestock output per £100 of feeding-stuffs was low due to wasteful feeding, and the same enterprises could have been kept with far less food. Finally, both net output per £100 labour and net output per £100 labour and machinery were low, and investigation showed an excess of labour.

Having found the reasons for the relatively poor results, the next stage was to find remedies, and this was done by preparing two or three budgets to see which of several alternative lines of action was likely to produce the greatest farm profit.

Both reports demonstrate how a farm business can be analysed simply and speedily. The two methods are similar but not identical. A close study of both, together with the examples provided, should reward both farmers and farm management advisers and assist them in their quest for higher productivity and higher profits.

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A.J.
L.N.

Pollination and Fruit Setting

The *Bartlett* (*Williams' Bon Chrétien*) pear is usually considered to be self-sterile, but in most Californian orchards it is self-fruitful by the production of parthenocarpic fruit. A near crop failure, in 1948, in orchards in the Sacramento Valley led to investigations by Griggs and Iwakiri [1] to determine the relative importance of self-pollination, cross-pollination and parthenocarpy.

Over a period of three years, it was found that over 75 per cent of the fruits were parthenocarpic in orchards with few or no pollinators; whereas in orchards with pollinators, less than 30 per cent were seedless.

Hand pollination showed that self-pollination did not give greater fruit sets than were achieved by vegetative parthenocarpy alone. The greatest parthenocarpic fruit sets were obtained in the more vigorous orchards, and it is suggested that orchard practices that improve vigour may be effective in producing a heavier fruit set where fruit setting is not adequate. Parthenocarpic *Bartlett* pears were found on average to have a better shape than seeded ones, and they reached picking size as early.

Parthenocarpy alone obtained a set that was considerably less than could be expected where proper provision was made for cross pollination. While in most years the set was adequate in the Sacramento Valley, the presence of pollinating varieties and bees may be valuable in improving crops in years unfavourable to setting.

The apple variety *Delicious* is much less dependable in fruit setting than *Golden Delicious* and *Rome Beauty*, and an investigation was undertaken by Hartman and Howlett [2] to determine the causes of this in the hope of assisting the grower to improve its setting. Examination of the flowers at various stages up to and shortly after petal-fall revealed that the ovules were often late in developing, and that they frequently degenerated; as many as 3 of the 10 ovules in each flower being in one or other of these conditions. If, in addition to this inherent loss of seed, the weather was unfavourable to pollination, there was a big risk that the fruit would have less than the 6 to 7 seeds that are considered necessary for it to develop to maturity. Other varieties, free from this inherent trouble, may mature enough seeds in spite of adverse weather. Although the grower could do little to influence the abortion of ovules, he could ensure the best possible conditions for pollinating the normal ovules by the provision of suitable cross-pollinating varieties and bees to transport the pollen.

Observations on the fertility of eleven French apple varieties by Coutaud [3] showed that climatic factors, especially temperature, greatly affect the dates of appearance and the duration of each stage of blossom development. The fact that all varieties are not equally affected

in this way has an important bearing on the suitability of varieties for cross-pollination. Low temperature has less effect on pollen germination, but with a few varieties germination was poor at 50°F. Hanging drop cultures of pollen grains to which a stigma was added showed that germination was depressed when the stigma was triploid or was of the same variety as the pollen. Germination of both diploid and triploid pollen was enhanced by the presence of a diploid stigma. It is suggested that the substances causing these effects on germination are hormonal, and that they play a part in self- and cross-incompatibility, parthenocarpy and metaxenia. The ability of the ovules of a variety to develop into seed showed no correlation with the percentage germination of the pollen of the variety.

Coutaud concludes that when planting an orchard, provision should be made for suitable cross-pollination, although high temperature (77°F.) at blossoming may, like freezing temperatures, favour the development of parthenocarpic fruit in a few varieties. In these experiments parthenocarpic fruits were formed only after pollination, which appeared to initiate the development of the pome.

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H.B.S.M.

Poultry Husbandry

Internal Egg Quality

Egg quality is a subject which commands much interest because of its great economic importance, and a number of recently published papers on the subject of internal egg quality are therefore of topical interest. In an account of "A Correlation between Egg Albumen Weight and Shank Width", by J. S. S. Blyth (*J. agric. Sci.*, 1955, **45**, 293-7), the author found in the inbred lines of Brown Leghorns used for the experiment, that the line means for albumen weight ranked in the same order as shank width. This similarity was not due to large differences in body weight, and it was noted that the close relationship observed did not exist to the same degree between albumen weight and yolk weight. The author also suggests that shell weight is closely related to albumen weight. On the same general subject—"Relations of Yolk, Albumen and Egg Weight"—J. E. Erasmus (*ibid.*, 1954, **45**, 32-5) also working with inbred

Brown Leghorns found that yolk weight varied little with variations in egg weight; the smaller eggs were characterized by a marked decrease in the amount of albumen. Hen eggs had a bigger proportion of yolk than eggs from pullets. ERASMUS also gives an account of a further investigation in a paper on "Shell Porosity and Shell Thickness" (*ibid.*, 1954, **45,** 28-31). In observations on eggs laid by the same flock he could find no significant relationship between shell thickness and porosity in March or July of the same year. He concludes that line differences in porosity values are attributable to variations in other properties of the shell. A further contribution on the subject dealing with "Sex-linked Association of Egg Weight and Body Weight" by R. OSBORNE (*Proc. Roy. Soc. Edin.*, 1954, Section B, **65,** 317-26) gives an account of work offering evidence of sex-linkage for egg weight but not for body weight.

Maintenance of Egg Quality

Dealing with another aspect of egg quality—"Maintaining Quality in Shell Eggs by Heat Treatment" (*Research Bull.* 550, *U. Missouri Agri. Expt. Stn.*, 1954)—E. M. FUNK, J. FORWARD and M. LORAH give an account of various treatments on the quality of stored eggs. The results confirm the findings of other workers that heavy losses through deterioration occur when both soiled and cleaned eggs are stored. Pasteurization was successful in preventing losses with eggs washed and pasteurized at various times up to 96 hours after soiling. If pasteurization only is desired, the eggs should be immersed in water for $1\frac{1}{2}$ hours at 150°F. One interesting finding by these workers was that stains could be removed from eggs by washing them in warm water containing 0.5 per cent sodium perborate. This had the effect of removing stains from the eggs, which then appeared in natural light to be equal in appearance to unwashed clean eggs. But the conditions relating to washed non-pasteurized eggs would still apply.

Shell Quality

"The Strength of the Shell of the Hen's Egg" by J. BROOKS and H. P. HALE (*Nature*, 1955, **175,** 848-9) describes an investigation into the relationship between shell strength and other factors. It has been known for some time that there is no relation between size of egg and strength of shell for eggs from the same species of bird. Differences in shell strength can only partially be explained by differences in shell thickness. Among the results recorded by these two workers is their finding that only about 58 per cent of the variance in strength can be attributed to differences in shell thickness. No relationship was found between strength and porosity. Emphasis is laid on the hardness of the outer part of the shell and the progressive softening towards the inner part of the shell. The magnesium content was greatest in the outer part of the shell, and progressively decreased towards the inner part.

Although the authors do not conclude from these results that magnesium levels may be a major factor in promoting shell strength, they indicate that the subject is worth further investigation.

On an allied problem—"A Further Study of the Effect of Sulphanilamide on the Metabolism of Calcium and Phosphorus in the Laying Hen"—C. TYLER (*J. agric. Sci.*, 1954, **45**, 156-63) points out that when sulphanilamide is fed to laying hens a decrease in calcium retention occurs and eggs are laid with thinner shells. The withdrawal of the drug from the diet immediately results in a return to the laying of eggs with normal shells. The return to normal calcium retention was generally slower, and, in consequence, the calcium balance may be adversely affected for some weeks after the withdrawal of the drug. Consequently, calcium metabolism and shell formation may also be influenced for a time after ceasing to supplement the diet with sulphanilamide.

R.C.

The Problem of Apple Scab Spraying

The problem confronting the apple grower (and the Advisory Officer) can be stated briefly: what is the best material to use and how may it be applied most efficiently and economically? Unfortunately, the answer is by no means simple and it is worth considering how far the results of recent research can help to provide it.

Available Fungicides

Before the war there was little choice of materials. Lime sulphur was most widely used; Bordeaux mixture had declined in popularity because of its difficulty in preparation, abrasive effect on spraying machinery, and tendency to cause damage. Lime sulphur still has many virtues. Provided that a good cover is obtained each season before infection starts, i.e., usually before the green cluster stage, and that the cover is maintained as the leaves develop, it gives a good protection against scab and some control of Apple Mildew and Red Spider. It is both cheap and persistent, so that in many cases not more than four applications are necessary. There is, however, one major disadvantage in the injury it may cause to some varieties, such as *Lane's Prince Albert* and *Cox's Orange Pippin*. The substitution of dispersible sulphur preparations in the post-blossom spray programme reduces the damage, but at the cost of more frequent applications or poorer scab control.

Development of organo-mercurial preparations such as phenyl mercury chloride at East Malling [1] provided a rival to lime sulphur. These compounds are in the same price range as lime sulphur, but tend to be less persistent and therefore require more frequent applications.

They have an advantage over lime sulphur in having an eradicant as well as a protective action. Therefore, unlike the case with the lime sulphur group, it may be possible to achieve a control after initial infection has taken place. The good results obtained by Storey [17] and others in the Wisbech area on *Bramley's Seedling* illustrate the value of this factor. Although these mercurial compounds may be applied safely to a wide range of varieties, they are liable to cause severe damage to *Cox's Orange Pippin*, particularly in wet seasons. Also they have no effect on Mildew and Red Spider.

Since the war, the introduction of a number of new compounds has widened the choice of materials considerably. Tetramethyl thiuram-disulphide (TMTDS), and other thiocarbamates such as zineb and ferbam have all shown comparative freedom from injury on sulphur-sensitive varieties and have given good scab control in a number of trials [2, 3 and 4]. Unfortunately, they have not given consistently good results under all conditions [1 and 5]. The glyoxalidine group of compounds have given satisfactory scab control and caused less injury than lime sulphur on both apples and pears in several seasons [3, 6, 7, 8, 9 and 10]. The most recent introduction is N-trichloromethylthiotetra-hydrophthalimide now available as captan. In a number of trials this material has given a better control of scab than lime sulphur and on *Cox's* a greater crop with no sign of injury [9 and 10]. However, these new materials are costly at present, and none of them appear to give any control of Apple Mildew and Red Spider [5 and 10].

The choice of material must be related to the needs of the individual orchard, but it seems possible to apply the results recorded above to various sets of circumstances. If no spray-sensitive varieties such as *Cox's Orange Pippin* are grown, lime sulphur would appear to be the most economic in view of its persistence and cheapness. If, however, there is difficulty in obtaining a complete spray cover, or if spraying has been delayed until after infection is present, there may be an advantage in using the organo-mercurial compounds. If, however, the varieties grown are susceptible to injury by either or both mercurial and sulphur compounds, the newer compounds, such as the glyoxalidines, may be the most economic. The increased cost of materials may be more than offset by increased yields of high-quality fruits. The situation is more complicated if Apple Mildew and Red Spider are present, as the omission of lime sulphur may permit them to increase. It may therefore be necessary to compromise by using lime sulphur in some years or retaining it regularly as a pre-blossom spray. Recent experiments at East Malling [11 and 12] suggest another future possibility as 2 : 4 dinitro-6 capryphenyl crotonate has given promising results in controlling Apple Mildew. Similarly, new acaricides are available for the control of red spider. Only further trials can decide whether the introduction of these new sprays, involving additional expense, will produce more economic results than using lime sulphur with its risk of injury.

Methods of Application

Experience has shown that hand-operated lances can give an excellent cover of sprays on fruit trees. However, this method is slow and requires well-trained operators. To speed up the operation and reduce the labour costs, automatic spraying machines have been developed. These developments have followed two lines. In the one method, high hydraulic pressure pumps are used to direct large volumes of spray fluid through an assembly of fixed nozzles. The second method, first developed in America, uses low hydraulic pressure and the spray droplets are carried to the trees by a large volume of air. This is the basis of the "speed" sprayer used in this country. Both methods have succeeded in reducing the time and labour required for spraying, but larger amounts of spray material are required to secure adequate coverage of the foliage. With the introduction of more costly fungicides, the waste of spray liquid assumes considerable significance. Attempts are therefore being made to perfect more economic machines using very small droplets. Kearns and his co-workers [13] have obtained promising results with an experimental air-flow machine with which 100-200 gal. dilute lime sulphur were used, instead of 600 gal. required by hand lance operators. Less satisfactory results were obtained in 1953 under conditions more favourable to scab attack [14]. Another aspect of this problem is revealed by the work of M. H. Moore [15 and 16] who has shown that low volumes of undiluted lime sulphur applied by an atomizer give a good control of scab without causing injury. The initial experiments carried out with a hand atomizer on small bush trees of *Cox's* have, in collaboration with the N.I.A.E., been extended with promising results to the use in plantations of large-scale machines delivering about 10 gal. per acre. It would seem, however, that the problems of spray drift with the small droplets used in low-volume machines have not yet been fully solved.

Here again, the results must be related to the requirements of individual plantations. For small areas the hand lance and skilled operator are probably still the best choice. With large orchards the necessity of spraying all the trees in the short time available for the pre-blossom sprays, and of maintaining a post-blossom cover in warm, wet conditions which are favourable to scab, indicates the use of automatic machines. It must be remembered that most of these high-volume machines are large and heavy and therefore require firm ground and adequate room in which to manoeuvre. Moreover, difficulties may be experienced in obtaining a complete cover on tall, dense trees. This difficulty increases with the low-volume sprayers, especially in exposed situations open to high winds. Last, but not least, the high capital cost of automatic sprayers must be weighed against the saving in time and labour.

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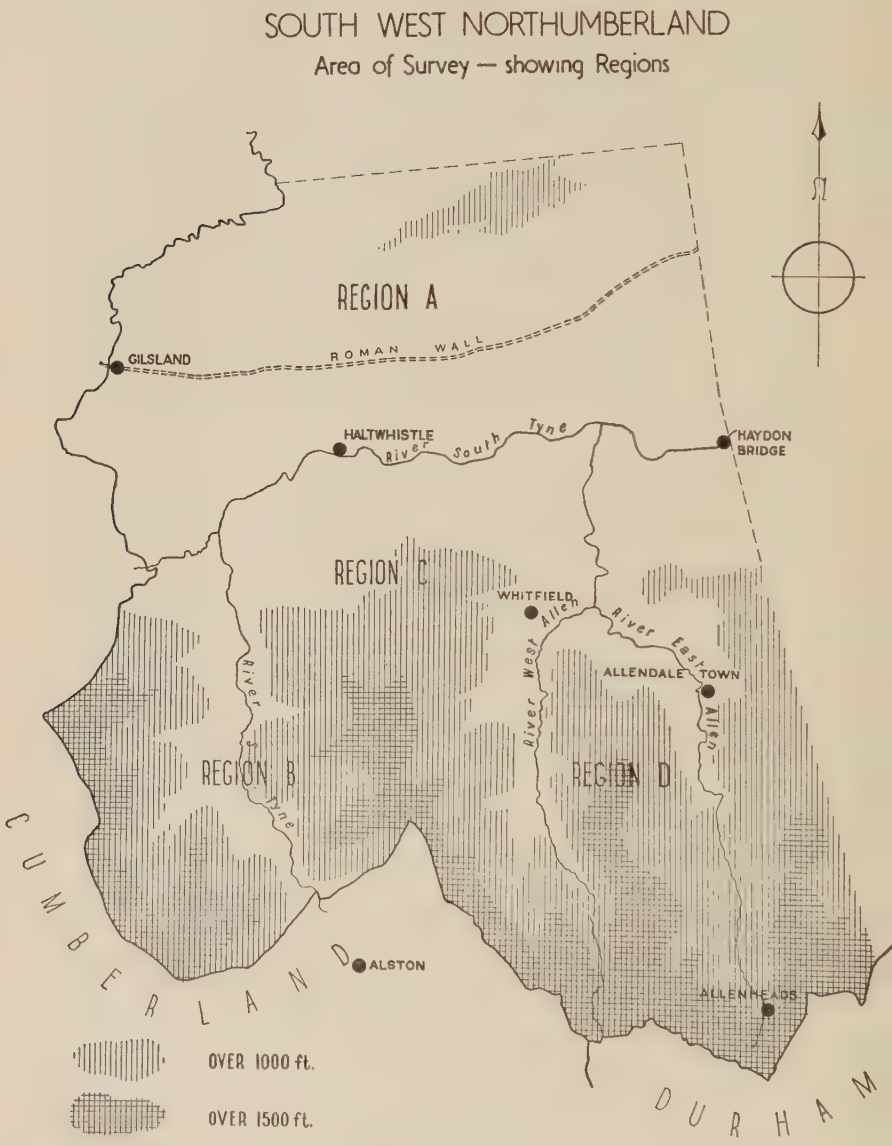
SOUTH WEST NORTHUMBERLAND
Area of Survey — showing Regions
N
REGION A
GILSLAND
ROMAN WALL
HALTWHISTLE
River South Tyne
HAYDON BRIDGE
REGION C
WHITFIELD
Allen
River West Allen
River East Allen
ALLENDALE TOWN
River Tyne
REGION B
REGION D
CUMBERLAND
ALSTON
ALLENHEADS
DURHAM
OVER 1000 ft.
OVER 1500 ft.

Provincial Note

A Survey of Hill Farming in South-West Northumberland

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SOUTH-WEST NORTHUMBERLAND, an area of some 140,000 acres, including approximately 700 holdings, is predominantly marginal and hill land. With the exception of some mixed farming in the valley of the South Tyne, and some Dales-type dairy farming in the Allendale area, the whole of the farming is devoted to the breeding of upland sheep and cattle of a hard type.

It is with the true hill farms—those normally eligible for Hill Sheep Subsidy—that this article is concerned.

The area bore its full share of the agricultural depression commencing in the last quarter of the nineteenth century, and, until comparatively recently, those who travelled its fells, allotments and inbye land could see the unmistakable signs in the tumbled-down stone dykes and here and there, the shells of buildings standing gaunt and open to the sky.

By 1940 the plight of hill farmers in Great Britain began to receive national attention. In 1941 the De La Warr [1] and Balfour of Burleigh Committees [2] were set up to examine the position and recommend remedial measures; in the same year the Hill Sheep Subsidy was introduced. Hill Cattle Subsidy followed two years later. The recommendations of the two Committees were embodied in the Hill Farming Act, 1946, whereby grants could be obtained for the rehabilitation of buildings, roads, and fences and for land improvement. This was extended by the Livestock Rearing Act, 1951.

The general economic position was further improved when, towards the end of World War II, sheep prices began to rise with the growing demand for stores from the lowlands, and the price of wool went up, due in part to the stock-piling policy of the Great Powers.

It is now pertinent to ask how and to what extent government policy and improved economic conditions generally have affected the pattern of hill farming. With these questions in mind, the writer carried out a survey in south-west Northumberland, with the twofold object of:

Recording the system of hill farming in the area as at 1952.
Noting changes in practice and production between 1939 and 1952.

The survey was based on sixteen farms representing an 8 per cent sample. These were chosen by taking a random sample of four farms from each of four regions (A, B, C and D), each area containing roughly the same number of hill farms (see map on p. 220).

Differences between the Regions

The differences between the regions arose mainly from physical variations such as climate, topography, altitude and soil.

Lambing times had the expected relation to altitude and exposure, being earliest in the lowest region and latest in the highest. The annual death rate of ewes followed the same trend. Lamb losses between birth and castration showed no group relationship. From castration to weaning losses were negligible in all regions, except on tick-infested holdings where the major cause was tick pyaemia. Regions A and D were found to be tick free.

An approximate estimate of fell herbage constituents over the area as a whole showed about 55 per cent white land (Bents, Fescues and Nardus), 28 per cent heather and 17 per cent moss, thus approaching ideal proportions. Three of the regions had a good mixed herbage, but in region A—the lowest lying of the four—heather was almost entirely absent, the herbage being predominantly Flying Bent (*Molinia caerulia*). This tended to cancel out the advantage of the better weather conditions in this region, as in-lamb ewes were entirely dependent on moss in the early part of the year, and the moss made little growth in very cold, or frosty weather.

Heather burning in the three regions was based on an eight-year rotation. In region D, because of the high rainfall, this objective was extremely difficult to achieve, even with the extension of the normal burning period. In all three regions there were holdings where difficulty arose through limitations imposed by the landlord, shooting tenant or gamekeeper on the grounds that game required older heather for food, although this theory was disproved as long ago as 1917 by Wallace [3]. Forestry Commission plantations bordered some of the holdings, and fear of causing damage to young trees deterred the occupiers from burning. Opinion was expressed that this would result in deterioration of herbage and ultimately of the sheep stock.

The fell management in regions A, B and C was very similar, each fell being enclosed by a boundary fence so that grazing could be controlled. In region D, however, the fell lying between 1,000 ft. and 2,000 ft. above sea level was communal grazing subject to restrictions as well as rights.

Hill Farming in the Area in 1952

In spite of regional differences outlined above, the hill farming systems over the whole area were basically similar.

All parcels of hill land had house and buildings attached in varying condition, with a hard road to almost every one. Each had an acreage of meadow, pasture and fell land, entirely enclosed, with the exception of the Allendale Stinted Pasture. Most farms had a few acres of tillage.

A flock of Scotch Blackfaced or Swaledale ewes in regular ages was maintained on every holding. The practice of taking the first lamb crop from the gimmers and of drafting at five-and-a-half years was general, except on very exposed fells where drafting was usual after three crops. For the last two lamb crops on the lower fells the Blue Faced (Hexham) Leicester ram was used to get an earlier-maturing lamb for sale. Lambing percentages varied from farm to farm, the average over a three-year period (1950-52) being 92 per cent, based on counts at the time of castration. This is probably higher than the norm over a long period.

Preference for away or home wintering of ewe hoggs varied. Whatever course was adopted depended mainly on the quality, quantity and exposure of the inbye land and the availability of away wintering. Farmers with less than two acres of in-bye land per ewe hogg did not seem satisfied with their progress at home.

Very little hand feed was offered to in-lamb ewes during winter, except in stormy conditions when grazings were under snow, but most ewes were taught to eat hay as hoggs. Possibly the fact that many ewes live at or near the bare subsistence level for two or three months in winter renders them more liable to disease. On the other hand, it is argued that artificial feed weakens the natural raking instinct and there is the practical difficulty on many farms of a severely limited meadow acreage.

All farms maintain cattle as well as sheep. Galloway suckling herds calving in spring predominate, except in the Allendales where Shorthorn herds produce milk for sale and calves are pail reared. Galloway bullocks are usually sold as weaned calves, the heifers ready to bull or in calf. Hay is the staple diet during winter, supplemented where available with oats, straw, roots and grass silage. Nearly all stock are wintered inside. A high proportion of the cattle is attested.

Management of Allendale Stinted Pasture (Region D)

The grazing unit of this common land, extending to 25,000 acres is the stint, an area 5 to 7 acres in extent, on which up to five adult sheep may be grazed. The stints are attached to valley farms and may be bought or rented from other stint occupiers. General control is exercised by a Stinted Pasture Committee composed of representatives of the stint holders. Inherent in the system and outside the control of the Committee, there are difficulties which militate against good sheep management. For example, anyone keen enough to improve his stints by cutting open drains, only attracts his neighbours' sheep to the detriment of his own. Anyone bringing in new stock after acquiring extra stints, is at

liberty to graze them along with his existing flock—obviously much the easiest from a shepherding point of view, but increasing the concentration of sheep to his neighbours' detriment.

Again, neighbouring flocks are frequently shepherded at different times of the day, and several flocks are disturbed on each occasion, thus interfering with the grazing and resting of the sheep. Moreover, such a large unfenced area makes it easier for disease to spread, and in fact some sheep-tick-infested fell land adjoins one corner of the Pasture. Rams are not permitted on the stints in autumn. Ewes have therefore to be brought on to the in-bye land for tupping, and this necessitates the early housing of cattle and adds to an already lengthy winter feeding period. Since the number of stints bears no relationship to the acreage of in-bye land, the latter is often heavily overstocked at the mating period. The ewe hoggs, if not wintered away, are brought in-bye after the ewes are returned to the fell. By this time the pastures are soiled, and unthrifty hoggs may quickly fall victim to heavy worm infestation. Lambing again has to take place in-bye on land only recently cleared of hoggs. The vicious cycle is completed by a delayed growth of grass in the spring, so that cattle are turned out late and hay crops are reduced. These are but a few of the arguments advanced by many stint occupiers in favour of enclosure.

Changes between 1939 and 1952

Marked changes have taken place. Many buildings have been renovated or enlarged to hold more stock or fodder. New buildings have been erected. Farmhouses and cottages were being renovated, making them less cold and damp and the amenities improved.

In 1939, a total of $5\frac{1}{2}$ acres were under the plough on the 16 surveyed farms. In 1952, there were 82 acres, plus a substantial amount of new leys sown down after wartime cropping. In addition many fields had been improved by surface treatment.

In the area as a whole, 12,500 chains of tile drains had been laid or renovated, and 176,000 chains of sheep drains cut since 1943.

Preventative measures against specific sheep disease had increased over the period, particularly against lamb dysentery, pulpy kidney and braxy, though some inoculation against lamb dysentery and black quarter in cattle had ceased without ill effect. The cost of veterinary medicines ranged from £7 16s. to £27 10s. per 100 ewes, the average being about £15 8s. The costs could not be related to regions, intensity of sheep stocking or total stocking on individual farms, although there was a suggestion that expenditure was higher on tick-infested farms.

In the late 1930s and early 1940s, many hill farmers in the area reduced the number of calves reared and started selling milk in the wholesale market, replacing their Galloway cows with Shorthorns. The profit from milk was greater than that from rearing, and the regular monthly payment made the extra effort attractive.

Milk production did not always fit in well with the hill farming system. Ewes and lambs had priority in spring with meadow and pasture grass, and lambs grazed some of the aftermath before the autumn sales. The cow grazing season was therefore short. The rough allotments were suitable for Galloways, but not always for Shorthorns. Inclement autumn weather reduced yields from grass, and the milk cows needed to be housed earlier than had been customary with Galloways, thus creating a bigger demand for winter fodder. The cake bill rose steeply, and on occasions hay had to be bought.

By 1950, however, there was a distinct swing towards rearing, due no doubt to the decreasing profitability of milk production and the rapidly rising prices for store cattle. The emphasis on attestation had increased and those farmers returning to a rearing policy endeavoured to purchase attested stock. The number of Galloway cattle, however, had been considerably reduced and demand exceeded supply. Prices rose quickly. It was not uncommon to find two Shorthorn heifers being sold to buy one attested Galloway. For this reason, there were actually more cattle on the farms in 1949 than 1952, but numbers will increase further with a more plentiful supply of attested Galloways.

Obviously a crucial question was how far the improved economic circumstances and the consequent expenditure on land improvement had affected the stock-carrying capacity of the farms. In view of the importance of this, additional information was collected from a further sample of 16 farms selected in the same manner.

Table 1

Summer Stock-Carrying Capacity in 1939 and 1952

*Sheep Equivalents per acre**

	Average per acre			Total Increase
	1939	1952	Increase	
1st sample ...	0.97	1.13	0.16	1,666
2nd sample ...	0.98	1.36	0.38	3,071

1st Sample. $t = 3.359$ $p = < 0.01$
2nd Sample. $t = 4.877$ $p = < 0.001$

**Sheep Equivalent:* Both sheep and cattle are included in the calculation, one mature beast being taken as equivalent to seven sheep.

The figures in Table 1 show that there had been a statistically significant increase in stock-carrying capacity. In terms of cattle the increase was equivalent to 238 mature cattle on the first group of 16 farms, and 439 on the second group.

It is well recognized that on this type of farm the limitation on stock-carrying capacity is in the amount of winter keep the farm can provide rather than the availability of summer grazing. Table 2 shows the extent to which there had been an improvement in this respect.

Table 2

Differences in Stock-Carrying Capacity in Winter 1939 and 1952

*Expressed in terms of Cattle Equivalents**

	1st Sample	*2nd Sample*
Total net increase	94	147
Average increase per acre of winter food produced	0.14	0.02

1st Sample. $p = < 0.02$ $t = 2.738$
2nd Sample. $p = < 0.02$ $t = 2.867$

**Cattle Equivalent:* Two stirks or four calves are taken as equal to one mature beast. Sheep are omitted, as not normally making much demand on winter fodder.

The increase in the winter carrying capacity of cattle is significant, and had been achieved by a combination of extending the fodder area and obtaining a higher yield per acre.

However, stock numbers are not the full story so far as production is concerned. There can be no doubt that if the increase could have been assessed in terms of liveweight output per acre, the improvement indicated above would be much more pronounced.

Summary

The survey showed that there had been little change in sheep management over the period. In cattle policy there had been a distinct swing from milk back to rearing. There was a marked improvement in the economic position and a consequent marked increase in production.

There are those who doubt whether the nation is getting value for money expended in the form of Government assistance to upland farms. It is not within the scope of this survey to answer that question. However, apart from increased production, it is almost certainly true that, without grant aid, some hill farms would now be unoccupied, to the detriment of lowland farms dependent on the hills as a reservoir for store and breeding stock.

The writer would agree with the sentiments expressed by the Duke of Northumberland a year or two ago: "The benefits to be derived from rehabilitation under the Hill Farming and Livestock Rearing Scheme have not made themselves felt in full measure as yet, and are unlikely to do so for several years; but there is ample evidence to show that this assistance will pay handsome dividends in the food production of this country."

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